Claims

1. A method for producing transparent p-Type conducting oxide films without co-doping, plasma enhancement or high temperature comprising:

a) introducing a dialkylmetal at ambient temperature in a carrier gas into a low pressure deposition chamber; and

b) introducing NO alone or with an oxidizer into said chamber under an environment sufficient to produce a metal-rich condition to enable NO decomposition and atomic nitrogen incorporation into the formed transparent metal conducting oxide.

2. The process of claim 1 wherein said dialkyl is selected from the group consisting of dimethyl and diethyl and said metal is selected from the group consisting of Zn, Cd, In, Sn, Ga and alloys thereof.

The process of claim 2 wherein said transparent conducting oxide is selected from the group consisting of ZnO, CdO, In_2O_3, SnO_2, Ga_2O_3 and alloys thereof.

3. The process of claim 3 wherein said carrier gas is selected from the group consisting of N_2 or Ar.

4. The process of claim 4 wherein in step b) NO is introduced alone.

5. The process of claim 5 wherein NO is introduced with an oxidizer.

6. The process of claim 6 wherein said oxidizer is O_2.

7. The process of claim 6 wherein said ambient temperature is about 23°C ± 2°C.

8. The process of claim 7 wherein said ambient temperature is about 23°C ± 2°C.

9. The process of claim 8 wherein said chamber pressure is about 30 torr.

10. The process of claim 9 wherein said chamber pressure is about 30 torr.

11. The process of claim 10 wherein total gas flow through said chamber during deposition is between about 2,000 to about 3,000 sccm.

12. The process of claim 11 wherein total gas flow through said chamber during deposition is between about 2,000 to about 3,000 sccm.

13. The process of claim 12 wherein said deposition temperature is between about 200 to about 550°C.

14. The process of claim 13 wherein said deposition temperature is between about 200 to about 550°C.

15. A p-Type transparent conducting oxide film consisting essentially of a transparent conducting oxide formed from a dialkyl metal and a NO doping source, said oxide and said NO doping source being grown without co-doping, plasma enhancement or high temperature and under an environment sufficient to produce a metal rich condition to enable NO decomposition and atomic nitrogen incorporation into formed transparent metal conducting oxide at over about 2 atomic %.

16. The film of claim 16 wherein said dialkyl is selected from the group consisting of dimethyl and diethyl and said metal is selected from the group consisting of Zn, Cd, In, Sn, Ga and alloys thereof.

17. The film of claim 17 wherein said transparent conducting oxide is selected from the group consisting of ZnO, CdO, In_2O_3, SnO_2, Ga_2O_3 and alloys thereof.

18. The film of claim 18 wherein said transparent conducting oxide is ZnO.

AMENDED CLAIMS

[Received by the International Bureau on 04 october 2002 (04.10.02):
original claims 1-18 replaced by amended claims 1-19]
and Statement

1. A process of using chemical vapor deposition for producing transparent p-type conducting oxide films without co-doping, plasma enhancement or the use of high temperature, comprising:

(a) introducing a dialkylmetal at ambient temperature in a carrier gas into a low pressure deposition chamber; and

(b) introducing NO alone or with an oxidizer into said chamber under an environment sufficient to produce a metal-rich condition to enable NO decomposition and atomic nitrogen incorporation into the formed transparent metal conducting oxide; said dialkyl is selected from the group consisting of dimethyl and diethyl.

2. The process of claim 1 wherein said metal is selected from the group consisting of Zn, Cd, In, Sn, Ga and alloys thereof.

3. The process of claim 2 wherein said transparent conducting oxide is selected from the group consisting of ZnO, CdO, In_2O_3, SnO_2, Ga_2O_3 and alloys thereof.

4. The process of claim 3 wherein said carrier gas is selected from the group consisting of N_2 or Ar.

5. The process of claim 4 wherein in step b) NO is introduced alone.

6. The process of claim 5 wherein NO is introduced with an oxidizer.

7. The process of claim 6 wherein said oxidizer is O_2.

8. The process of claim 6 wherein said ambient temperature is about 23°C ± 2°C.

9. The process of claim 7 wherein said ambient temperature is about 23°C ± 2°C.

10. The process of claim 8 wherein said chamber pressure is about 30 torr.

11. The process of claim 9 wherein said chamber pressure is about 30 torr.

12. The process of claim 10 wherein total gas flow through said chamber during deposition is between about 2,000 to about 3,000 sccm.

13. The process of claim 11 wherein total gas flow through said chamber during deposition is between about 2,000 to about 3,000 sccm.

14. The process of claim 12 wherein said deposition temperature is between about 200 to about 550°C.

15. The process of claim 13 wherein said deposition temperature is between about 200 to about 550°C.

16. A p-type transparent conducting oxide film consisting essentially of a transparent conducting oxide formed from a dialkyl metal and a NO doping source, said oxide and said NO doping source being grown without co-doping, plasma enhancement or high temperature and under an environment sufficient to produce a metal rich condition to enable NO decomposition and atomic nitrogen incorporation into formed transparent metal conducting oxide at over about 2 atomic %.

17. The film of claim 16 wherein said dialkyl is selected from the group consisting of dimethyl and diethyl and said metal is selected from the group consisting of Zn, Cd, In, Sn, Ga and alloys thereof.

18. The film of claim 17 wherein said transparent conducting oxide is selected from the group consisting of ZnO, CdO, In_2O_3, SnO_2, Ga_2O_3 and alloys thereof.

19. The film of claim 18 wherein said transparent conducting oxide is ZnO.

STATEMENT UNDER ARTICLE 19(1)

International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20,
SWITZERLAND

Sir:

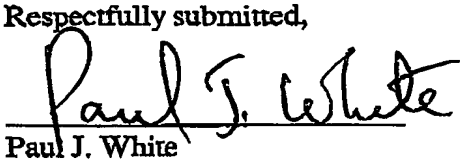
The Yan et al., reference, referred to under the DESCRIPTION OF PRIOR ART section of applicant's specification is merely a hypothetical assessment that relates to control of doping by impurity chemical potentials, and achieves doping ZnO using N_2 and N_2O to theorize that the use of dilute NO or NO_2 gas would resolve the long-standing problem of achieving p-type ZnO; however, no where in this reference is there any mention of or reference to, producing transparent p-type conducting oxide films without co-doping, plasma enhancement or the use of high temperature by introducing a dimethyl or diethyl metal at ambient temperature in a carrier gas into a low pressure deposition chamber, followed by introducing NO alone or with an oxidizer under an environment sufficient to produce a metal-rich condition, to enable NO decomposition and atomic nitrogen incorporation into the form of a transparent metal conducting oxide, as presently recited in applicant's claims. Accordingly, the Yan et al. document, while relevant is nevertheless insufficient when compared to applicant's claims as presently recited, to deprive applicant's claims of an inventive step when the document is taken alone, since Yan et al. clearly lacks the step a) of applicant's claims and does not teach how to form p-type ZnO by MOCVD technique.

U.S. Patent 5,756,207 A, upon review disclose a process for contacting the substrate with a transition metal oxide precursor, in a vaporous form and/or in a liquid form and/or in a solid (e.g., powder) form, to form a transition metal oxide precursor-containing coating on the substrate; contacting the substrate with at least one interacting component and contacting the coated substrate with an oxidizing agent to form a transition metal oxide-containing coating and recovering a coated substrate, and/or semi conductors having a defect and/or non-stoichiometric structure which enhances conductivity. The contacting of the substrate with the transition metal oxide precursor and with the interacting component can occur together, i.e., simultaneously, or in separate steps. The electrically conductive coated substrate is then recovered.

Again, no where in the '207 patent is there any reference to or mention of, producing transparent p-type conducting oxide films in the absence of co-doping, plasma enhancement or high temperature by introducing a dimethyl or diethyl metal at ambient temperature in a carrier gas into a low pressure deposition chamber, followed by introducing a NO alone or with an oxidizer under an environment sufficient to produce a metal-rich condition to enable NO decomposition and atomic nitrogen incorporation into the formed transparent metal conducting oxide. Since reference '207 clearly lacks step a) of applicant's claims as presently recited and does not teach how to form p-type ZnO by MOCVD. Thus, this document is insufficient to preclude applicant's process from involving an inventive step when the document is taken alone.

In view of the foregoing amendments, remarks, and arguments, and in view of submitted replacement pages 17 and 18, containing the amended claims, it is believed that application as amended clearly defines an inventive step over the cited references.

Respectfully submitted,



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Dated: October 4, 2002.

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